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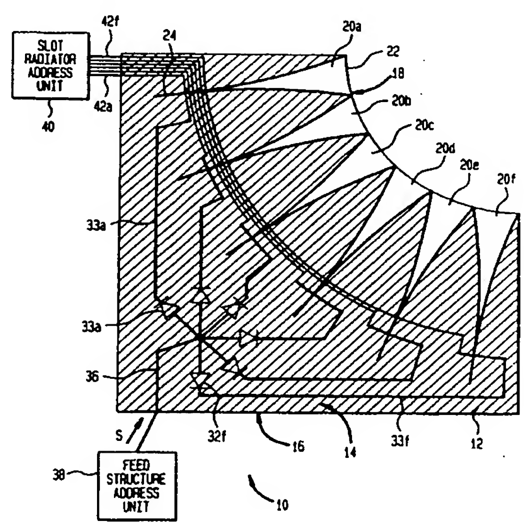
(54) A feed structure for use in a wireless communication system.

(57) A feed structure for use in a wireless communication system for transmitting and receiving a data signal. The feed structure (10) includes a dielectric substrate (12) having a lower surface (16) upon which a conductive material is disposed, an upper surface (14), and an edge (18). A plurality of slot radiators (20), each having a wide end (22) coterminous with the edge (18) and a narrow end (24), is etched into the conductive material. A switching mechanism is provided for connecting the narrow end of a selected slot radiator to an input bus containing a signal so that a relatively narrow beam is caused to propagate from the wide end of the selected slot radiator.

FIG. 1



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FIELD OF THE INVENTION

The present invention relates to feed structures for wireless communication systems. The present invention is more particularly directed to a specific feed structure arrangement for generating a plurality of narrow scannable beams.

BACKGROUND OF THE INVENTION

Recent experimental designs for wireless high speed indoor communications systems (WHSICS) dictate the need for a narrow scannable beam to reduce distortion in the transmitted and received signals. Beams having a beamwidth of approximately 15° or less have been found to be most effective for this purpose. The basic architecture of such WHSICS consists of a community of wireless subscribers communicating between themselves and/or others on a general network through a central base station. One way of obtaining a narrow scannable beam is by employing phased array antennas either at the base station, at the subscribers' terminals or, most preferably, at both the base station and the subscriber terminals. A significant practical drawback of this approach, however, is that employing phased array antennas significantly adds to the cost of such WHSICS.

An alternative to phased array antennas is to form a multitude of narrow beams (each with a beamwidth of approximately 15° or less) and to switch between the narrow beams to determine a suitable transmission and reception path. Multiple beams may be generated using multiple horn feeds (i.e. one beam per horn feed) and, when used in WHSICS wherein a hemispherical scan region is required, the beams are arranged to span a hemisphere through the use of a spherical lens. However, the use of multiple horn feeds --which are bulky and expensive -- arranged about a spherical lens not only adds to the size of the overall WHSICS but, in addition, significantly increases the cost of the system. Accordingly, it would be desirable to have a compact and readily manufacturable feed structure capable of generating a plurality of narrow beamwidth beams for use in WHSICS.

SUMMARY OF THE INVENTION

The present invention is accordingly directed to an advantageously configured feed structure for use in a wireless communication system. The feed structure comprises a dielectric substrate having an upper surface, a lower surface and an edge, a conductive layer disposed on the lower surface, and a plurality of slot radiators formed within the conductive layer. Each slot radiator has a wide end positioned at the edge of the substrate and a narrow end. The feed structure also includes means disposed on the upper surface of the substrate and responsive to a control signal for selectively directing a main signal to the narrow end of a selected one of the slot radiators so that, when the control signal is applied, a beam of radiant energy is caused to propagate from the wide end of the selected slot radiator.

In the currently preferred embodiment, a plurality of the inventive feed structures are provided in conjunction with a constant dielectric spherical lens for operative use in determining a most desired or suitable transmission and receiving path for a data signal. The feed structures so employed have an edge conformed to fit the curvature of the lens.

Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference characters denote similar elements throughout the several views:

FIG. 1 depicts a feed structure constructed in accordance with the teachings of the present invention;

FIG. 2 depicts a plurality of the inventive feed structures arranged about a spherical lens; and

FIG. 3 depicts a hemispherical arrangement of narrow beamwidth beams arranged about approximately one-third of a hemisphere of a spherical lens.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and initially to FIG. 1, a feed structure 10 constructed in accordance with the teachings of the present invention is there shown. As so depicted, the feed structure 10 includes a substrate 12 constructed from a dielectric material such as a synthetic polymer resin, e.g. polytetraflouroethelyne (PTFE), and having an upper face or surface 14, a lower face or surface 16 and an edge 18 defined between the upper and lower surfaces and configured in a predetermined shape or contour as more fully discussed below. The lower surface 16 of the substrate 12 has a thin layer of conductive material, such as copper, disposed thereon and in which six separate slot radiators 20a - 20f are etched in a manner well known to

those of ordinary skill in the art. As shown, each slot radiator 20 has a wide end 22 coterminous with the edge 18, and a narrow end 24. Also as known in the art, the width of each slot radiator 20 is designed to operatively emit a beam having a predetermined narrow beamwidth.

With continued reference to FIG. 1, the upper surface 14 of the feed structure 10 contains a directing means comprised of a plurality of diodes 32a - 32f, the cathode of each being connected to an input bus 36 and the anode of each being connected to a respective designated conducting line 33a - 33f. Each conducting line 33 is disposed in conducting relation with the narrow end 24 of a respective slot radiator 20 via microstrip or stripline connections as for example described in Knorr, Slot-Line Transitions, IEEE Transactions on Microwave Theory And Techniques, pp. 548-54 (May, 1974) and Mariani, et. al., Slot Line Characteristics, IEEE Transactions on Microwave Theory And Techniques, pp. 1091-96 (December, 1969). A slot radiator address unit 40 is provided to address a desired slot radiator 20 via respective bias lines 42a - 42f so that a main signal S, which may be a data signal or a test signal, will be provided to a selected one of the slot radiators 20 in a manner more fully described below. Inasmuch, as it is additionally contemplated that a plurality of such feed structures 10 will be employed in a given communication system, a feed structure address unit 38 is provided for addressably accessing a particular feed structure 10 for supplying the main signal S thereto. Although it is generally anticipated that a plurality of feed structures 10 will be employed at both the transmitter and receiver, the use of such structure 10 at only one or the other is also within the intended scope of the invention.

When a plurality of feed structures 10 are employed in an indoor communication system in accordance with the present invention, the system uses the multiple narrow beams generated therefrom to scan the environment for determining the most efficient receiving and transmitting path for a data signal. Thus, in use, the feed structure address unit 38 addresses a desired feed structure 10 and provides thereto a signal S, comprising a test signal, through an input bus 36. The test signal is converted to a narrow beam via transmission through a selected one of the slot radiators 20 by addressing the particular slot radiator through address unit 40. Thus, a beam is transmitted individually from each of the slot radiators 20 from one feed structure 10 to the next until the most desired transmitting and receiving path is determined, i.e. that the path which yields the minimum amount of multipath rays. As will be readily appreciated, other scanning sequences may alternatively be employed such as transmitting from the slot radiators 20a in each structure 10, then transmitting from the radiators 20b in each structure 10, etc. In the preferred embodiment, scanning is conducted at both the transmitter and receiver. Thus, once the most desired beam direction -- corresponding to a particular slot radiator in the transmitter and in the receiver -- has been determined, data is communicated via the main signal S to the input bus 36, and transmitted through the selected slot radiator of the transmitter and received by the selected slot radiator of the receiver.

As stated above, in WHSICS hemispherical scanning arrangements are used to maximize the scanning capabilities. Such hemispherical scanning may for example be implemented through the use of a spherical lens. While a Luneburg lens is particularly suitable for this purpose, such lenses are difficult and costly to manufacture. As an alternative, a constant dielectric spherical lens may be employed in conjunction with a plurality of the inventive feed structures 10 as depicted in FIG. 2. As there shown, therein, half of a spherical lens 50 having a constant dielectric is surrounded by a plurality of feed structures 10 each capable of emitting a plurality of beams having narrow beamwidths through slot radiators 20a - 20f. As will be appreciated, when such a lens configuration is employed, the edge 18 of the feed structures 10 is conformingly shaped to match the curvature of the lens. To obtain maximum scanning, the individual feed structures 10a - 10x are arranged on or along a hemisphere, i.e. half of the lens 50, so that the beams generated therefrom cover the surface area of the opposite (i.e the scanning) hemisphere. This implementation is depicted in FIG. 3 which illustrates 1/3 of the scanning hemisphere of the spherical lens 50. As shown, the plurality of individual beamwidths 52 of the beams generated from the plural slot radiators 20 in the plural feed structures 10 substantially blanket the scanning hemisphere of the lens 50. It has been found that one way of maximizing the scanning region of such a spherical lens 50 formed of a constant dielectric material is by utilizing 24 separate feed structures 10 arranged on 90° great circle arcs positioned on meridian lines of the spherical lens 50 and configured as follows: three feed structures 10 with six beam feeds (i.e. six slot radiators), nine feed structures 10 with five beam feeds, and twelve feed structures 10 with three beam feeds, yielding a total of 99 beams. It is, of course, within the intended scope and contemplation of the invention that additional arrangements of feed structures 10 may alternatively be employed for different hemispherical coverage, as is generally known in the art. However, arranging the feed structures as described hereinabove results in a structure in which the generated narrow beams form a plurality of

parallel rings on and about the hemispherical surface parallel to the equator of the spherical lens 50 and yields optimal scanning capabilities.

Accordingly, as should now be appreciated, by utilizing the feed structure 10 constructed in accordance with the present invention multiple beams can be generated from each feed structure. Moreover, the inventive construction and arrangement notably increases the scanning capabilities of a WHSICS employing such feed structures and, by virtue of the relatively low cost and ease of manufacture of the inventive feed structures through known etching techniques, results in a significant reduction in the cost of such WHSICS.

While there has been shown and described and pointed out fundamental novel features of the invention as applied to currently preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form of details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, the feed structure 10 may also be used in conjunction with lenses other than spherical lenses. In such cases, the edge 18 may be configured accordingly, i.e. to substantially conform to the surface shape of the particular lens. Moreover, additional or fewer slot radiators 20 may be employed in each feed structure 10. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

Claims

1. A feed structure for use in a wireless communication system, comprising:

   a dielectric substrate having an upper surface, a lower surface and an edge;

   a conductive layer disposed on said lower surface;

   a plurality of slot radiators defined in said conductive layer, each said slot radiator having a wide end located proximate said edge of said substrate and a narrow end; and

   means for selectively directing a main signal to the narrow end of a selected one of said slot radiators for causing a beam of radiant energy to propagate from said wide end of said selected slot radiator, said directing means being disposed on said upper surface of said substrate.

2. A feed structure for use in conjunction with a lens having a predetermined shape in a wireless communication system, said feed structure comprising:

   a dielectric substrate having an upper surface, a lower surface and an edge having a shape substantially conforming to the predetermined shape of the lens and positioned in close proximity to the lens;

   a conductive layer disposed on said lower surface;

   a plurality of slot radiators defined in said conductive layer, each said slot radiator having a wide end located proximate said edge of said substrate and a narrow end; and

   means for selectively directing a main signal to the narrow end of a selected one of said slot radiators for causing a beam of radiant energy to propagate from said wide end of the selected slot radiator through said lens, said directing means being disposed on said upper surface of said substrate.

3. The feed structure of claim 1 or 2, wherein said directing means comprises means for switching between said plurality of slot radiators so as to select a selected one of the slot members.

4. The feed structure of claim 3, wherein said switching means is disposed in conductive relation with said narrow ends of said plural slot radiators.

5. The feed structure of claim 2 or 4, wherein said switching means is operatively responsive to a control signal for directing said switching means to access said selected one of said slot radiators and so that the main signal is applied to the narrow end of said selected slot radiator.

6. The feed structure of claim 2, wherein the lens is spherical-shaped and wherein said substrate is positioned on a meridian line of the lens.

7. The feed structure of claim 6, wherein the lens is constructed of a constant dielectric material.

8. A wireless communication system for transmitting and receiving a data signal and for use in an indoor environment, comprising:

   a receiver; and

   a transmitter,

   wherein at least one of said receiver and transmitter comprises a lens having a predetermined shape and a feed structure, said feed structure comprising

   (a) a dielectric substrate having an upper surface, a lower surface and an edge having a shape substantially conforming to the predetermined shape of the lens and positioned in close proximity to said lens;

   (b) a conductive layer disposed on said lower surface;

(c) a plurality of slot radiators defined in said conductive layer, each said slot radiator having a wide end located proximate said edge of said substrate and a narrow end; and

(d) means for selectively directing a main signal to the narrow end of a selected one of said slot radiators for causing a beam of radiant energy to propagate from said wide end of the selected slot radiator through said lens to determine a most desired transmitting or receiving path of the data signal, said directing means being disposed on said upper surface of said substrate.

9. The communication system of claim 8, wherein the predetermined shape of said lens is a sphere and wherein said lens is constructed of a constant dielectric material.

10. The communication system of claim 9, wherein said feed structure comprises a plurality of feed structures and wherein said plurality is positioned about meridian lines on a hemisphere of said spherical lens.

FIG. 1

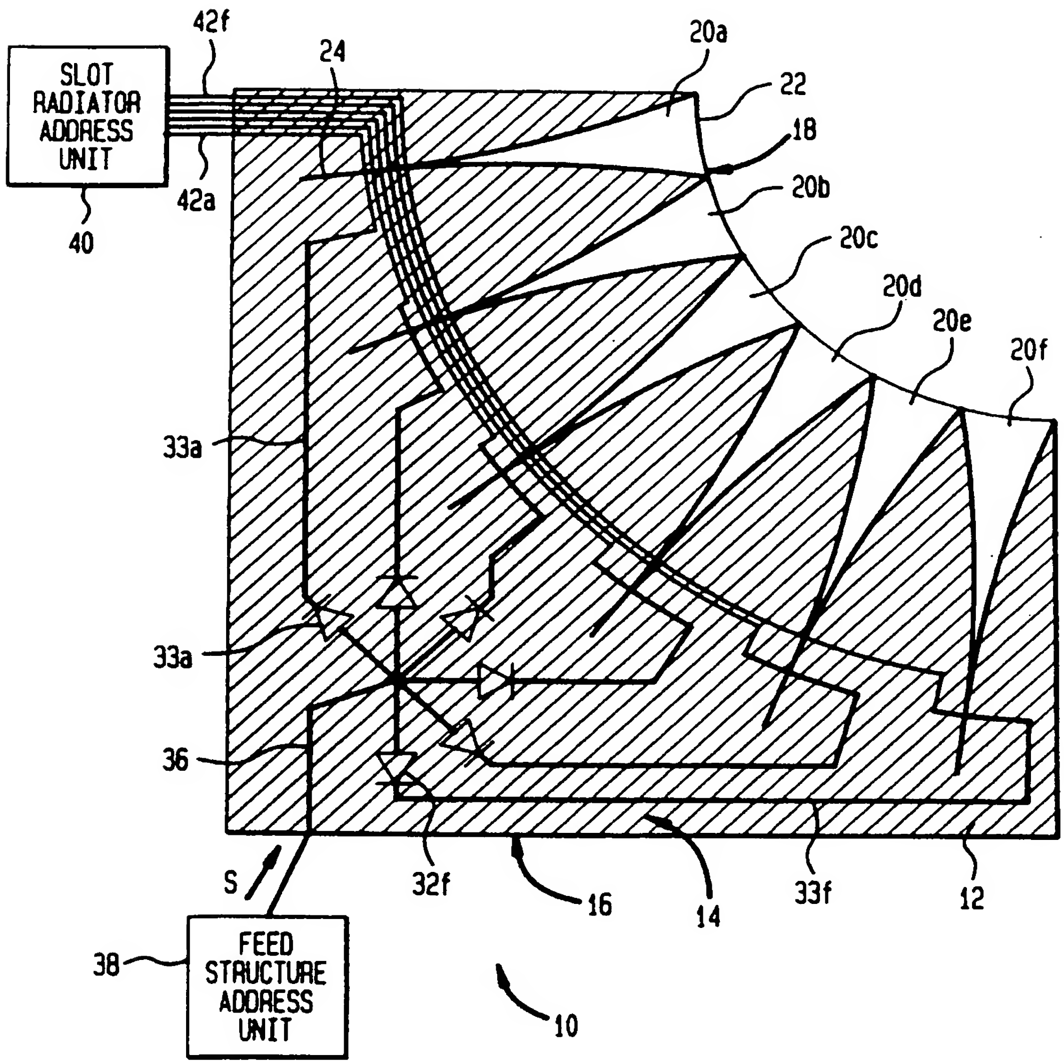
SLOT RADIATOR ADDRESS UNIT
42f
24
20a
22
18
20b
20c
20d
20e
20f
42a
40
33a
33a
36
S
32f
16
14
33f
12
38
FEED STRUCTURE ADDRESS UNIT
10

FIG. 2

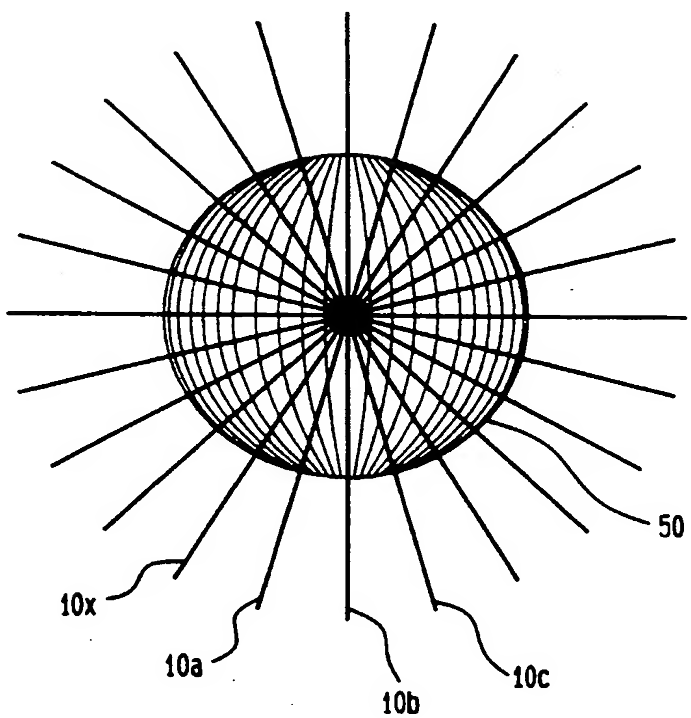

FIG. 3